NAS Operational Implementation Plan

September 26, 1997

Executive Summary

Purpose

This document identifies:

- the minimum standards, guidelines and procedures that AVR and Aviation System Standards must develop to implement satellite navigation in the NAS; and
- the support required by these services to accomplish this work in a timely manner.

Coverage

The major orders, certification criteria, and evaluation guidelines required to evaluate cockpit avionics, the operations for which these avionics are proposed for use are tabulated with their estimated times of completion. Flow charts illustrate the relations of these products to one another and to user requirements, or to significant implementation milestones. Technical and informational support required for timely preparation of these products is also identified.

Tables and flow charts also present the process required for:

- the development of WAAS instrument approach standards; and
- the design and flight inspection of precision and non-precision approaches required for an equivalent level of service to 4100 runway ends currently supported by conventional NAVAIDs.

WAAS commissioning July 1999 and LAAS IOC in the year 2001 are assumed as bases for determining completion dates for the tabulated products and activities.

Approach

Information contained in this document was obtained through discussions with members of the Satellite Implementation Team responsible for the identified work, and through reference to the FAA's *Plan for Transition to GPS-Based Navigation and Landing Guidance* and the *GPS Implementation Plan for Air Navigation and Landing*.

Products

Products to be developed by the Aircraft Certification Service include the following:

- Technical Standard Orders for receivers, antennas, and sensors;
- Guidelines for the use of these TSOs by Agency certification specialists in equipment certification, and
- Advisory Circulars informing applicants about how certification criteria may be satisfied

Products to be developed by the Flight Standards Service include the following:

- Terminal instrument approach criteria for GPS and WAAS;
- GPS and WAAS additions to inspectors' handbooks to provide criteria for evaluating training curricula, maintenance practices, and proposed operations by air carrier and general aviation applicants.
- Standards for operations specifications for air carrier flights; and, where resources permit,
- Advisory Circulars describing acceptable means for meeting various evaluational criteria.

Aviation Systems Standards will design and flight check GPS/WAAS approaches at 50 runway ends before WAAS commissioning, and a total of 500 precision approaches and 500 non-precision approaches will be developed and flight checked each year thereafter until a total of 4100 runway ends are supported by GPS/WAAS by the year 2008.

Table of Contents

Figures

NAS Implementation Plan

1. Introduction

This plan identifies the minimum guidance and controls that Federal Aviation Administration (FAA) must develop in order to implement the use of the satellite navigation in the National Airspace System (NAS). Through its Satellite Navigation Program, the FAA is developing new capabilities that will provide significant economic and safety benefits to the entire aviation community. To realize these benefits at the earliest possible date, the FAA is working concurrently on the technical and operational aspects of satellite navigation implementation. The present plan primarily addresses the operational aspects of this program.

2. History

The FAA has embarked on an aggressive program to make satellite-based navigation technology available for use throughout the NAS. It is working with the aviation industry to augment the Global Positioning System (GPS) to provide navigation services adequate for all phases of flight.

The potential application of satellites in civil aviation has been the subject of numerous studies since the late 1960s. These early efforts were constrained by the high initial costs of researching, developing, and establishing a satellite constellation and ground infrastructure large enough to support civil aviation needs. In addition, the high cost of satellite navigation receivers relative to ground-based system receivers further inhibited the introduction of a satellite-based system.

These obstacles have been largely overcome as a result of the development and deployment of GPS by the Department of Defense (DoD). Advances in digital technology and the already large civil GPS user base have led to the introduction of cost-competitive avionics with capabilities and performance that surpass those available from conventional, ground-based systems.

The FAA, along with the International Civil Aviation Organization (ICAO) and other members of the civil aviation community, has recognized that a Global Navigation Satellite System (GNSS) will provide the primary stand-alone navigation system in the 21st Century. GNSS is an evolving system, building on the initial foundation of available state-provided systems such as the United States (U.S.) GPS and the Russian Global Orbiting Navigation Satellite System (GLONASS). These initial systems may be augmented with other satellite systems as they become available and are needed to meet increased requirements for availability, continuity of service, accuracy, and integrity.

3.1 Development and Implementation of Satellite Navigation

The FAA's approach to the introduction of satellite navigation has been careful and evolutionary with safety of flight as the highest priority.

During the early stages of implementation, the FAA limited GPS to supplementary use. The FAA chose this incremental approach to:

- obtain early operating experience in a safe and controlled flight environment;
- promote research in GPS operations; and
- introduce the flying community to the benefits of GPS operations.

The FAA approved the use of GPS as a multi-sensor in oceanic and domestic en route airspace in fiscal year 1991 (FY91), and for non-precision approaches in the following year. To further clarify operator requirements, the FAA has issued Advisory Circular (AC) 90-94, "Guidelines for Using Global Positioning System Equipment For IFR En Route and Terminal Operations and For Nonprecision Instrument Approaches In The U.S. National Airspace System."

In 1992, the FAA approved GPS for use as one sensor in a multi-sensor navigation system, such as the flight management system (FMS). Additionally, the FAA authorized aircraft on oceanic flights that required two long-

range navigation (LRN) aids to use GPS as one of their LRN aids. In June 1993, the FAA approved GPS for use as a supplemental means of navigation, with the stipulations that aircraft using supplemental GPS have on board:

- a GPS receiver that meets the requirements of Technical Standard Order (TSO) C129, and
- an approved primary means of navigation.

Near the end of FY93, the FAA allowed the use of GPS as a supplemental means of navigation during all phases of flight except precision approach. Early in FY94, the DoD declared that GPS had achieved its initial operational capability (IOC). Shortly thereafter, the FAA announced that GPS was an integral part of the NAS.

In December 1994, GPS was approved for use as a primary means of navigation in oceanic airspace and remote areas, with some limitations.

In FY99, the FAA will begin to operate a Wide Area Augmentation System (WAAS) to augment the basic GPS radionavigation signals. This will permit the use of GPS as a primary means of navigation in all phases of flight except precision approach. WAAS will ultimately enable the use of GPS for Category I (CAT I) precision approaches.

WAAS provides the additional accuracy, availability, integrity, and continuity of service required to use GPS for navigation throughout the NAS. Through a network of precisely surveyed ground locations, information in the WAAS message improves the accuracy of the GPS signal. This increased accuracy enables users to rely on GPS as the primary means of navigation when ceilings are as low as 200 ft. and visibility is down to 1/2 mile for qualified airports. It provides a capability for developing more standardized precision approaches, missed approaches, and departure guidance for more than 5,000 runways and more than 3,000 heliports in the NAS.

WAAS also provides increased accuracy in position reporting, allowing for more uniform and high-quality air traffic management (ATM). In addition, WAAS has the potential to provide benefits beyond aviation to all modes of transportation, including maritime, highway, and railroad.

Table 1 shows these milestones and other important developments chronologically.

Table 1, Milestones in Satellite Navigation

February 1978	GPS satellite, NAVSTAR 1 (Navigation Satellite Timing and Ranging) launched
March 29, 1978	NAVSTAR 1 declared operational
February 1991	FAA approved GPS for use as an input to a multi-sensor receiver system
late 1991	At the request of the FAA administrator, the Radio Technical Commission for Aeronautics (RTCA) formed a special task force to formulate a consensus strategy for early implementation of a GNSS capability in the U.S.
December 1992	GPS approved as a supplemental navigation system for oceanic, en route, terminal, and non-precision approaches
June 1993	FAA approved supplemental use of GPS down to non-precision approaches (RTCA Minimum Operational Performance Standards DO 208 and FAA TSO-C129)
December 1993	GPS declared to have IOC with 24 satellites
February 1994	First GPS receiver certified for flight operation through non-precision approach
May 1994	Test bed data met FAA WAAS specification of 7.6 m horizontal and 7.6 m vertical
June 1994	Requests for Proposals for the WAAS were issued
September 1994	GPS with local differential augmentation approved for special-use CAT I (SCAT I) precision approaches
December 1994	GPS approved as a sole-means navigation system for oceanic flight
August 1995	Award of WAAS development contract
July 1999	WAAS Commissioning
2001	Local Area Augmentation System (LAAS) IOC

2005	Decommissioning of ground-based navigational aids (NAVAIDs) begins
2007	Equivalent level of service WAAS three-dimensional (3D) and GPS/WAAS two-dimensional (2D) approaches at 4,100 runway ends
2010	Rapid decommissioning of ground-based NAVAIDs begins

3. Benefits and Justification

Full implementation of satellite navigation will bring major safety and economic benefits to all sectors of the aviation community. Cockpit avionics will be more affordable. Position information will be more precise and more available to flight crews, and routes of flight will be more direct and less constrained by the line-of-sight characteristics of conventional NAVAIDs, and airports currently without precision approaches will be able to have them at little expense.

3.1 The FAA

Satellite-based systems will replace costly ground-based navigation and surveillance systems. The new systems will reduce ATC operations and maintenance (O&M) costs 10 to 30% per year, as facilities are simplified, procedures are streamlined, and the work force is reduced accordingly.

3.2 Air Traffic Operations

Air Traffic will be more responsive to the needs of pilots and the communities they serve. The routing flexibility and increased surveillance capability provided by satellite navigation will:

- allow more efficient use of airspace;
- provide air traffic services at currently uncontrolled airports; and
- allow the use of lower altitudes to accommodate pilot requests and reduce airspace congestion.

3.3 Benefits for Users

Direct routing, precision approaches and continuous flight monitoring into all large and small airports will provide passengers with more flight options, shorter routes and the highest levels of safety under all flight conditions.

3.3.2 Pilots and Air Carriers

General aviation pilots, air carrier pilots and aircraft owners will have reduced training requirements and less expensive avionics requirements because of the seamless operations permitted by a single navigation system.. Precision approaches into all airports and continuous monitoring by air traffic control (ATC) will increase flight safety and efficiency. Cockpit map displays enabled by satellite navigation technology will increase pilot situational awareness and reduce pilot workload.

The economical benefits of satellite navigation will be especially profound for the commercial airlines. They include:

- Reduced flying times and fuel consumption resulting from the freedom to select fuel-efficient altitudes, and possible reductions in fuel reserve requirements;
- Lower equipment and training costs; and
- Improved airport access.

3.3.3 Military Aviation

Examples of military benefits include direct cost savings from being able to use off-the-shelf (OTS) avionics to equip their fleets. Operational benefits include GPS-enabled ATC automation that can handle complex airspace allocation procedures while segregating military and commercial aircraft to ensure safety.

3.3.4 Airport Authorities and Regional Economies

WAAS and LAAS provide the means for precision approaches into airports that cannot afford conventional ground-based NAVAIDs, as well as those located in the midst of terrain that excludes radar monitoring and the use of such NAVAIDs. This capability will promote the use of smaller airfields, new air routes, and corresponding services. These new services will result in not only the expansion of existing markets, but also the creation of new markets and the shifting of business centers from major metropolitan areas to smaller cities.

Satellite-based navigation will allow smaller regional airfields to accommodate increases in traffic demands at a fraction of the cost of expanding existing large airport facilities. Smaller local airports in the vicinity of major metropolitan areas will be able to attract regional air carriers because of their newly acquired instrument approach capabilities. The network of feeder and commuter operations that link hundreds of smaller cities to each other as well as to hub airports will dramatically increase.

3.3.5 Aircraft Manufacturers

The rapid expansion of regional airlines, coupled with increased small airport operations, will invigorate the regional aircraft manufacturing industry. Small airfield operations will stimulate the development of new classes of regional aircraft. For the first time, it will be possible to justify the costs of producing high-speed passenger and cargo aircraft capable of vertical take-off and landing. Moreover, these new aircraft will be quieter and more acceptable to operate near residential neighborhoods.

Satellite navigation technology will also increase the economic feasibility of developing and constructing new vertiports. Currently, vertiports primarily serve offshore oil rigs, medical emergency sites, and major airports located in close proximity. Even these services have been limited, because most heliports do not have precision instrument approaches. WAAS and LAAS will eventually provide that capability, which will further transform the aviation infrastructure. Extensive use of vertiports will create an even greater network of commuter and feeder operations, extending the business network ever outward from metropolitan areas. Even mountainous or heavily forested areas will be well connected to the aviation infrastructure.

4. Requirement for a plan

The FAA can ensure the safety and efficiency of satellite navigation only through the development and application of requirements and criteria for equipment, operations, and procedure design and evaluation.

The FAA cannot authorize satellite-based operations until:

- Aircraft Certification has the criteria and procedures for certifying airborne equipment developed by manufacturers;
- The Flight Standards Service has the guidelines and procedures for approving the means and conditions of use of that equipment; and
- Air traffic control establishes the procedures for ensuring the absence of air traffic and terrain conflicts by the users.

The details of these three domains must be interdependent, mutually supportive, and sufficiently comprehensive to permit the integration of satellite navigation into the NAS while phasing out navigation based on conventional ground facilities. This document identifies a means of ensuring that guidelines, procedures, and agency skills are in place for the timely and graceful integration of satellite navigation into the NAS. It also provides a reference source for information on current plans for implementation.

Previous FAA satellite navigation plans have emphasized the development, establishment, and positioning of GPS technology for use in aviation navigation. They have addressed the policies and schedules according to which the FAA plans to deploy that technology. They provide little information on how the FAA will achieve these objectives.

The current "Plan for NAS Operational Implementation" specifies how the FAA will implement the new technology operationally. This specification is primarily in terms of documents describing design requirements and rules of equipment use. The plan also identifies important tangible milestones that the FAA must accomplish

prior to the completion of these documents. Example types of documents include technical standard orders, advisory circulars, inspector handbooks, information publications for pilots, and aeronautical charts. Implementation of the new technology is completely manifested in its documents. In addition, the plan for the development of these documents is the road map for implementation.

5. Authority of the Plan

The FAA has the responsibility and statutory authority to establish, operate, and maintain navigation capability for all phases of flight.

The usefulness of this plan as a tool for exercising this responsibility derives from presidential policy, the FAA's operational responsibilities for flight navigation, and the GPS Integrated Product Team's (IPT's) operational mission.

On March 29, 1996, the President of the United States issued Presidential Decision Directive (PDD) NSTC-6, which presented a strategic vision for GPS. Among other things, this PDD reaffirmed the national commitment to promote GPS as a system that satisfies both national military and civil objectives. The PDD also highlighted national goals for GPS as a means of supporting and enhancing economic competitiveness and productivity. To foster these goals, the President encouraged acceptance and integration of GPS into peaceful, civil, commercial and scientific applications worldwide. The PDD also emphasized the use of GPS to enhance safety and efficiency in worldwide transportation as well as advancing U.S. scientific and technical capabilities in the appropriate international forums.

The mission of the IPT includes conducting the necessary research, development, acquisition, test, and management activities to enable the operational use of satellite navigation for all civil aviation needs.

6. Implementation Expertise

The IPT recognizes that users and customers will benefit from satellite navigation at the earliest possible time if the appropriate operational elements of the FAA participate in developing and implementing GPS and WAAS technology. Most of the technical expertise required for this implementation is resident in the Agency. These experts serve on the following different teams formed to address separate operational areas critical to implementation:

- Satellite Operational Implementation Team (SOIT)
- Satellite Procedures Implementation Team (SPIT)
- Technological Requirements and Implementation Team (TRAIT)

6.1 SOIT

The FAA established the SOIT to guide the safe and effective implementation of satellite navigation technology into the NAS. The SOIT recommends policy and suggests actions for member organizations in the area of satellite navigation. It assisted in the publication of TSO C-129 and has recommended policy regarding GPS non-precision approaches that have been produced as overlays and stand-alone procedures. The SOIT will continue to participate in all activities leading to the timely introduction of satellite navigation into the NAS.

Example Functions

SOIT functions include the following:

1. Assess the adequacy of existing FAA policies and procedures for aircraft systems, operations and maintenance, and air traffic management, and recommend changes as needed.
2. Provide guidance in directing the development of industry and government standards and consider them for possible adoption or reference in FAA policies and procedures.
3. Provide guidance in directing the research and development of satellite navigation technologies.
4. Investigate means to assess the impact on safety from a total system perspective.

5. Investigate the impact of a dynamic, evolutionary environment on the total system, including performance, reliability, integrity, and safety.
6. Provide technical information to other offices, as necessary, such as the Office of Aviation Policy, Plans, and Management Analysis (APO), which analyzes costs and benefit.
7. Identify major issues that cross organizational boundaries and recommends solutions.
8. Develop, review, and recommend technical guidance for Advisory Circulars (ACs), notices, Technical Standard Orders (TSOs), policy, rulemaking, and other technical documents.
9. Provide a forum for technical studies, reviews, and research.
10. Assist Services and Offices to carry out recommendations, as appropriate.

Membership composition

The SOIT includes FAA experts in avionics certification, operational approval, instrument flight procedures, air traffic, airway facilities, and other related operational disciplines.

6.2 SPIT

The SPIT is an interdisciplinary working group that reviews standards, provides guidance for GPS instrument flight procedures, and identifies and resolves operational issues relating to GPS implementation. Recommendations of the SPIT are referred to individual organizations or the SOIT, as appropriate, for action.

Example functions

The SPIT addresses issues that influence the nature and development of GPS/WAAS instrument approach procedures. These include the following:

1. Layout of instrument approach plates
2. Oversight of development of instrument approach procedures
3. Design of standard instrument approach procedures
4. Determination of approach procedure and charting terminology
5. Establishment of site development priorities

Membership composition

SPIT membership consists of procedure experts from flight standards, air traffic, aviation system standards, airports, and aircraft certification.

6.3 TRAIT

The TRAIT provides the leadership role in coordinating the operational implementation of existing and emerging technology into the Airway Facilities (AF) infrastructure. The TRAIT is the single focal point for implementation requirements for facilities and ensures that a process for implementation is in place. Activities relating to requirements for implementation of GPS are referred to the TRAIT for review and concurrence. As the AF focal point for operational implementation, the TRAIT provides guidance and direction to the offices responsible for the development, research, and acquisition of advanced technology systems within the NAS. The TRAIT has the authority to task AF and ARS member organizations to support agreed-upon decisions and activities.

Example functions

TRAIT functions include the following:

1. Assess the adequacy of existing FAA policies and procedures for Airway Facilities and recommend changes as needed.
2. Provide advice and guidance to industry and government in applications of advanced technology.
3. Provide expertise and information to other FAA organizations, as necessary.
4. Identify major issues that cross organizational boundaries and recommend solutions.

5. Develop, review, and recommend technical guidance for Advisory Circulars (ACs), notices, Technical Standard Orders (TSOs), policy, rulemaking, and other technical documents.
6. Provide a forum for technical studies, reviews, and research.
7. Assist services and offices to carry out TRAIT recommendations, as appropriate.

Membership composition

The TRAIT includes a chairperson selected by AAF-1, as well as representatives from AOP, AFZ, AOS, ANS, ASR, PASS, GNAS, ARTCC, AVN, and AND-510. This core of experts has the authority to act for their respective organizations.

7. Operational Implementation Requirements

7.1 Scope, Contents, and Use

The following sections of this plan identify:

- the operational implementation schedule;
- the operating capabilities to be provided according to that schedule; and
- the major guidance, directives, and agency capabilities required for implementation.

These aspects of implementation are the responsibilities of the Agency service areas concerned with certification and standards, operations, and approach procedure development.

The plan tabulates major products required to implement satellite navigation with their estimated dates of completion. Flow charts illustrate the relationship of these products to one another and to user requirements, or to significant implementation milestones. The plan also tabulates technical and informational support that would facilitate the development or use of enabling products. The IPT will support these activities, given the availability of sufficient funds and the relationship of the activities to implementation goals.

These schedules and the associated status updates are the major tools for oversight of implementation progress. Changes in completion schedules will have a major impact on IPT support priorities and estimates of when the NAS will be available for full WAAS implementation.

The readers of this plan should include product team members, members of the implementation teams, and personnel responsible for facilitating implementation through product development. The reader of this plan may use it to determine if:

- all documentation required for implementation has been identified;
- the dates associated with the different products are timely and support other activities dependent on their completion; and
- sufficient technical information and staff resources are available to meet the specified development and completion schedules.

7.2 Implementation Schedule

The schedules of product and capability development included in this plan were determined by:

- the availability of a viable signal in space for navigation;
- the schedule of decommissioning of ground-based NAVAIDs specified in the 1994 Federal Radionavigation Plan; and
- the time necessary for development of the requirements and guidelines defining the conditions under which satellite navigation could be used.

The most recent schedule for WAAS commissioning Plan indicates that the FAA will commission the WAAS system for use as the primary means for navigation on July 25, 1999. This date coincides with the publication cycle of Instrument Approach Procedure Charts. The next 58-day publication cycle starts during the following

September. These dates are important because they are times when the latest GPS WAAS approaches must be published if they are to be available for use by commissioning. The development of receiver certification criteria, operations and training requirements, and GPS 2D and 3D approaches are targeted to this date.

Except for guidance required specifically for LAAS, most of that required for the implementation of satellite navigation will be in place by the commissioning date.

This plan is based upon the following dates of performance:

1. WAAS will be commissioned on 25 July 1999 and available as primary means of navigation.
2. Initial operational capability (IOC) for LAAS will occur during 2001.
3. Satellite navigation will provide a level of service equivalent to that currently provided by ground-based NAVAIDs by 2007. At this time, each of 4100 runway ends will have 3D and GPS/WAAS approach procedures. Fifty runway ends will be completed by June 1999, and 500 runway ends will be completed each year thereafter until equivalence of service has been achieved.
4. Although selected Very High Frequency (VHF) Omnidirectional Range (VOR) stations and Instrument Landing Systems (ILSs) may be decommissioned prior to 2005, aggressive decommissioning of conventional NAVAIDs is scheduled to be completed during the year 2010.

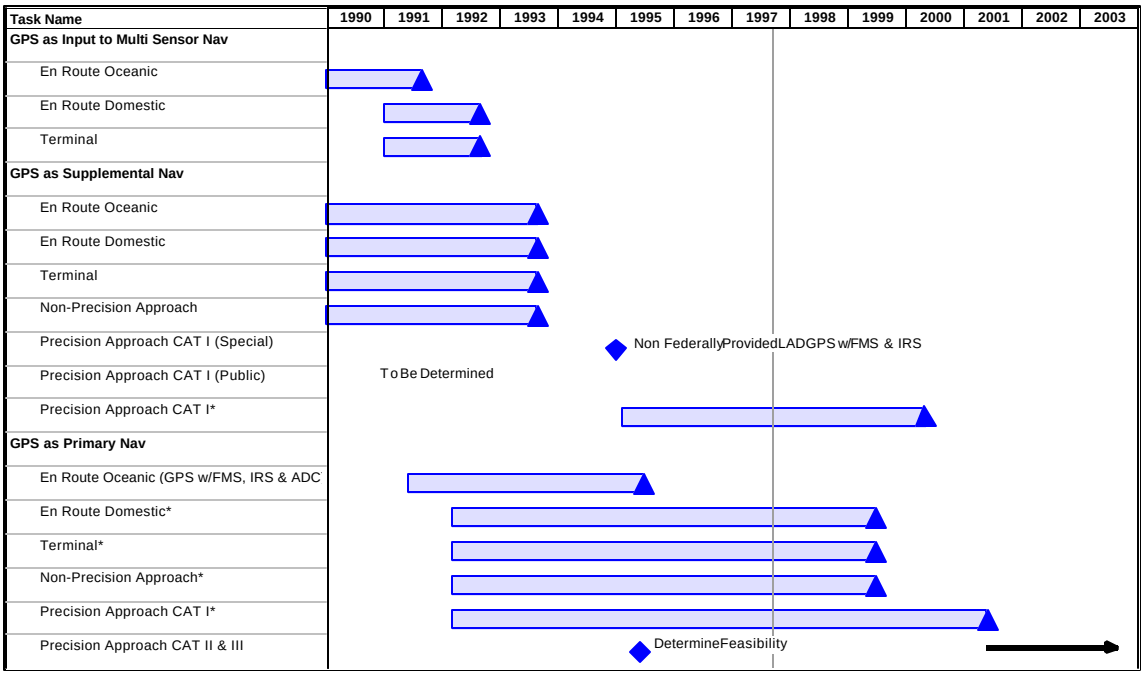
7.3 Operating Capabilities

This plan is designed to provide for the following operating capabilities by July 1999:

1. Part 121 operators will have all the directives and guidance necessary to make precision approaches with certified WAAS receivers, using published approach plates and fully trained flight crews.
2. Part 91 operators will be able to make 2D or 3D WAAS approaches as described in AC61-27 and the Airman's Information Manual, using TSO C-146-certified receivers.

Figure 1 illustrates the historical and anticipated schedule of GPS operating approvals.

Figure 1, Schedule of GPS Operating Approvals



7.4 Implementation Process, Products, and Schedule

7.3.1 Standards And Certification

The Aircraft Certification Service provides fundamental support for the safe implementation of satellite navigation. It works with industry to develop the Minimum Operational Performance Standards (MOPS) for the equipment receiving and processing the satellite signals. It supplements these guidelines with TSOs, which ensure that equipment designed in accordance with the MOPS is technically safe. It develops ACs, which describe to manufacturers and other users acceptable means for satisfying design criteria specified in TSOs and other related orders. When answers to questions about the safety of certain design characteristics are not readily available, it may sponsor and direct the research required to resolve such uncertainties.

A computer simulation of the WAAS receiver was developed as a test bed to validate the MOPS and to identify the need for additional design criteria. Change 2 to DO 229 includes changes indicated by this validation exercise. The prototype receiver developed from this change is used in collecting system performance data in flight. These data will be used as the basis for the system performance standards from which the GPS/WAAS Terminal Instrument Procedures (TERPS) will be developed.

Having participated in the development of the MOPS, manufacturers often are well along in the design and manufacture of avionics before the FAA publishes certification criteria and associated explanatory materials. Nevertheless, the manufacturers cannot finish avionics designs prior to the publication of these definitive guidelines, so the availability of the publications paces the development of GPS/WAAS receivers. It is probably unreasonable to expect the receivers to be available less than six months after the publication of these directives. Figures 1a and 1b indicate the sequence of these activities. The particular aspects of the system addressed by ACs is determined by the nature of the system, its potential applications, and the resulting likely need for guideline clarification.

Figure 2, Sequence of Standards, Advisory Documents, and Support Activities Essential to the Development and Installation of WAAS Receivers Certified for 2D Approaches

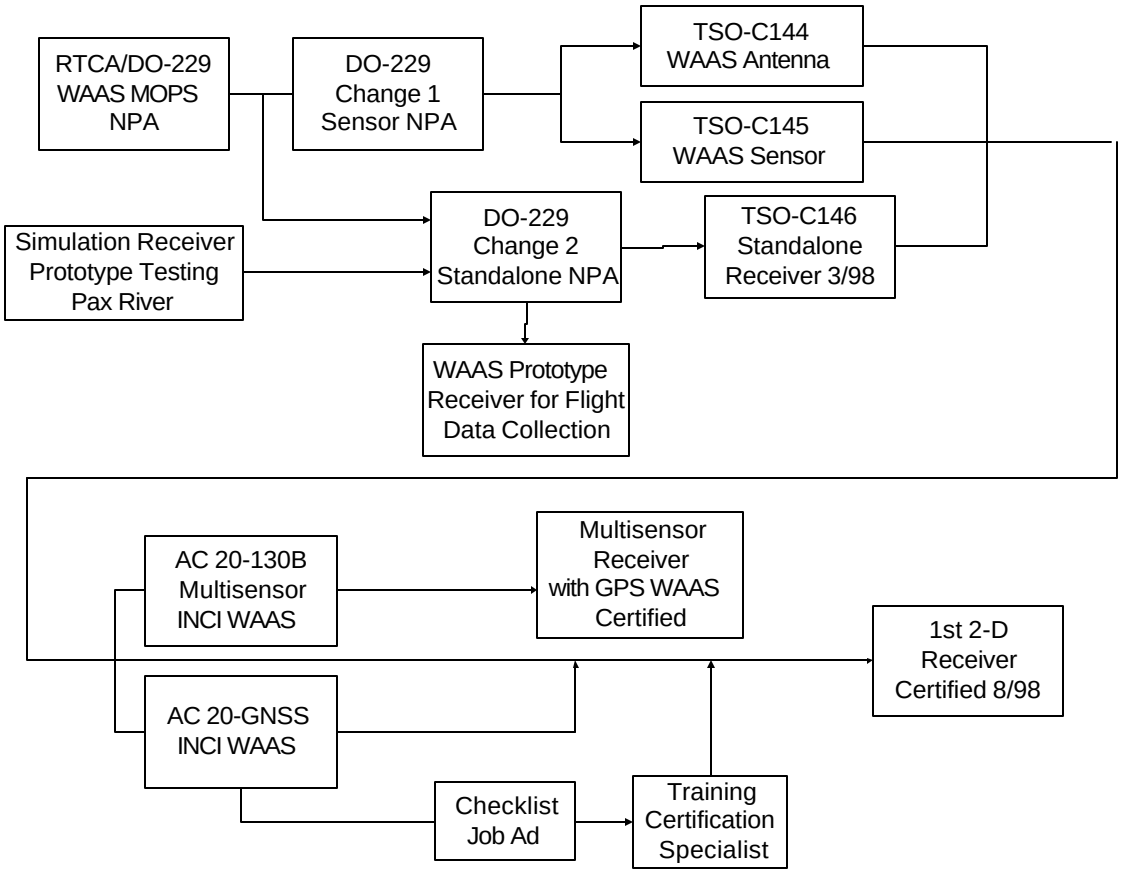
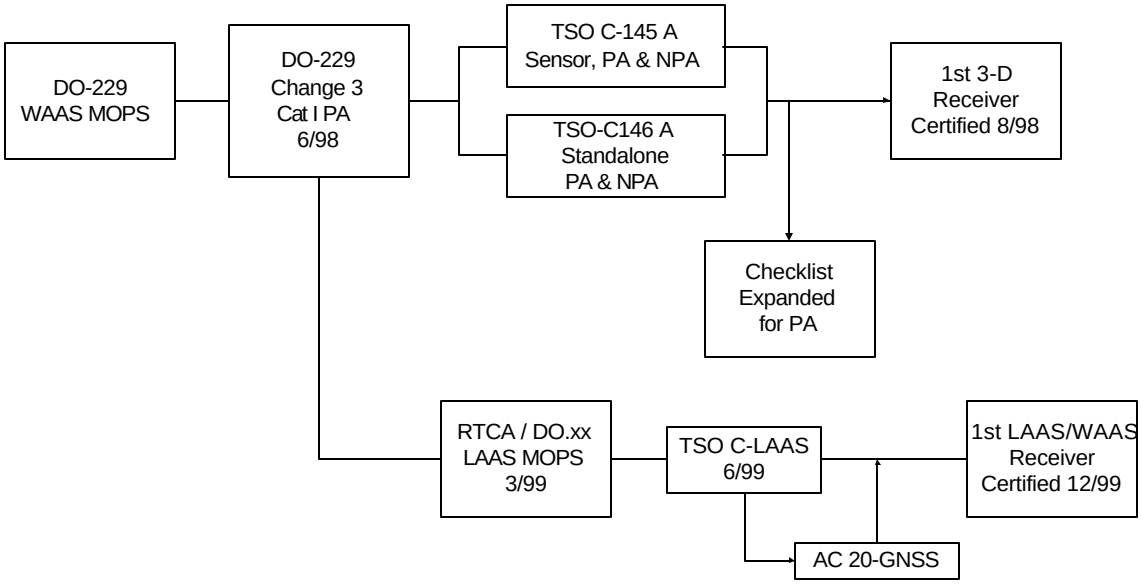


Figure 3, Sequence of Standards and Advisory Documents Essential to the Development and Installation of WAAS Receivers Certified For 3D Approaches



WAAS receivers are complex, and manufacturers may use a variety of engineering approaches to address Agency design requirements. There will be therefore be questions or disagreements concerning the compliance of newly designed equipment with the standards, which may delay equipment certification. Variations in guideline interpretation will lead to non-standard application of TSO criteria. As indicated in Figure 2, these concerns have been anticipated and addressed. A checklist job aid should be develop to assist the certification specialist in interpreting TSO requirements and to provide a standard approach to evaluating receivers for certification. Certification Specialists should also receive training in the use of the checklist. Initially, the checklist will address only the 2-D WAAS receiver. The checklist will be updated for 3-D receivers following the preparation of TSO-C146a. Figure 3 illustrates the planned flow of guidance development for WAAS implementation. Tables 2 and 3 provide the schedule for these activities and identify the person to contact regarding the developmental status of the material.

Table 2, Guidance and advisory publications for GPS/WAAS receivers designed for non-precision approaches and RNAV

Document/Activity	Contact	Pub. (CY)
RTCA/DO-229 (WAAS MOPS, NPA)	DeCleene	1/17/96
DO-229, Change 1 (sensor, NPA)	”	2Q97
WAAS prototype receiver testing	”	3Q97
DO-229, Change 2 (stand-alone, NPA)	”	4Q97
TSO C-144 WAAS antenna	”	3Q97
TSO C-145 WAAS sensor	”	3Q97
TSO C 146 WAAS standalone	”	1Q98
WAAS certification checklist	”	1Q98
AC 20-GNSS (up to & including WAAS)	”	2Q98

Table 3, Guidance and advisory publications for GPS/WAAS and LAAS receivers designed for precision and non-precision approaches

Document/Activity	Contact	Pub. (CY)
DO-229, Change 3 (Cat I PA)	DeCleene	2Q98
AC 20-130B Multi-sensor (incl. WAAS)	”	2Q98
TSO C-145A (WAAS sensor, NPA & PA)	”	ch3+6 mos.
TSO C-146A (WAAS stand-alone, NPA & PA)	”	ch3+6 mos.
RTCA/DO-xxx (LAAS MOPS)	”	2Q98
TSO C-LAAS	”	1Q99
AC 20-GNSS A (revised to include LAAS)	”	2Q99

Table 4, WAAS Certification activities requiring funding support

Activity	product supported
Participation in RTCA meetings	MOPS
Human factors in GPS operations	GPS/WAAS TSO, MOPS, WAAS checklist
GPS/WAAS checklist 2-D	TSO C146 WAAS stand-alone (NPA)
GPS/WAAS checklist change 1	TSO C146a (pa)
Training program for DERs and Certification Specialist	TSO C146 and C146A and checklist job aid
Beta /Gamma receiver development, simulation, and flight test	MOPs change 3, TSO C-146, 146a
Map display R&D	Cert. criteria

7.3.2 Operations

Flight Standards Service is the regulatory body within AVR that is responsible for the safety of flight operations. It executes this responsibility by setting certification standards for air carriers, commercial operators, air agencies, and airmen. It directs, manages, and executes certification, inspection, and surveillance activities to ensure the adequacy of flight procedures, operating methods, airman qualification and proficiency, aircraft maintenance, and the maintenance aspects of continued air worthiness programs. Under this broad responsibility, the Division of Technical Programs (AFS-400). is primarily responsible for guidance regarding the application of new technology to flight systems. AFS-400 develops policy and evaluation criteria necessary to ensure that the application of advanced technology to all-weather

operations, communications, navigation, and surveillance does not detract from the safe and efficient conduct of flight operations.

Flight Standards is also responsible for the development of obstruction clearance criteria for the design and charting of instrument approach procedures. These responsibilities will be address in Section 7.3.3, Flight Procedures.

A fundamental set of policies, directives and guidance material is required to establish implementation policy, operating limits, and requirements. Where clarification is necessary, advisory circulars describing acceptable means of compliance with these directives may be published. There is, however, no regulatory requirement to publish such advisory material.

The integration of a new technology into the National Aviation System is, ideally, formally initiated through a letter that describes Flight Standards Service policies regarding the application of the technology to flight operations. The FAA implements the policy through orders written to establish the requirements necessary for operations approvals. It may use notices to provide interim changes to orders. The order provides the requirement and the authority for AFS to develop more specific guidance on the installation, use, and maintenance of the new equipment. Where policies and other guidance establishing the FAA's position regarding the implementation of GPS may extend to systems developed to augment that navigation technology, policy guidance specific to WAAS and LAAS may not be required. In the case of GPS, the Presidential Decision Directive of March 26, 1996, established national transportation policy by reaffirming the national commitment to promote GPS as the primary military and civilian navigation system.

Specific tasks often accomplished by AFS to support the operational implementation of new cockpit technology include the following:

1. Developing orders to provide guidance for certification and criteria for the implementation of national policy where it influences aviation operations.
2. Informing the aviation public regarding the acceptable conduct of those operations.
3. Revising the Airman Information Manual to provide the general aviation pilot with tutorial guidance on operating rules and requirements.
4. Issuing FAA Operations Specifications to air operators holding certificates under 14 CFR Parts 121, 125, 129, and 135, when all certification, training, and other qualification requirements are met.
5. Publishing advisory circulars to provide guidance to applicants on acceptable ways to accommodate new operating and training requirements.
6. Developing performance specifications and test standards for evaluating the proficiency of pilots relevant to flight operations.
7. Providing guidance for Flight Standards Safety Inspectors for evaluating system users' equipment and qualifications for using required technology, and training them in the use of this guidance.
8. Revising the general aviation, maintenance inspectors', and air carrier inspectors' handbooks to cover the evaluation of proposed operations, procedures and training for users of the new systems. (Handbook supplements may be used to provide timely guidance to inspectors between handbook changes.)

The tables shown below identify the most essential guidance material required for the operational implementation of GPS/WAAS and LAAS. Secondary material developed to supplement and extend this guidance will be identified at a later date as new operational issues are uncovered.

Required implementation guidance

The schedule assumes that Commissioning will be in July 1999. That date drives estimated completion times, which are scheduled in time to provide the guidance necessary to permit WAAS-assisted flights during the first quarter of 1999. The following tables indicate:

1. requirements for NAS compliance for current operations including CAT I approaches;
2. requirements for CAT II and III approaches; and
3. the technical support necessary to ensure timely completion of the required guidance material.

Table 5, Primary Policy and Guidance Materials for the Implementation of GPS/WAAS into the NAS

Guidance Documents	Contact	Compl
AIM/AIP for GPS/WAAS RNAV	AFS-450	12/98
AC 90-94 rev (guidelines for en route, term, approach)	AFS-400	12/98
Practical Test Standards (reviewed and changed if reqrd).	AFS-630	
Instrument Flying Handbook	AFS-630	
GA Insp. Handbook or HBGA (8700.10)	AFS-800	12/98
Air Carrier Insp. Handbook or HBAT (8400.10)	AFS-200	12/98
Maintenance. Insp. Handbook or HBMA (8300.10)	AFS-350	12/98
FAR 121/129/135/ Ops Specs	AFS-260	12/98
FAR 125 Ops Specs	AFS-800	12/98

Table 6, Primary Policy and Guidance Materials for the Use of GPS/LAAS in CAT II and CAT III Operations

Guidance Documents	Contact	Compl
AIM for CAT II and CAT III	AFS-400	
AC 90-94 rev, CAT II and CAT III	AFS-400	
AC 120-29 CAT II and CAT III	AFS-400	
Practical Test Standards (rev and change if req.)	AFS-630	
GA Insp. Handbook or HBGA	AFS-800	10/00
Air Carrier Insp. Handbook or HBAT	AFS-200	10/00
Maintenance. Insp. Handbook or HBMA	AFS-350	10/00
FAR 121/129/135/ Ops Specs	AFS-260	3/99
FAR 125 Ops Specs	AFS-800	3/99

It is imperative that personnel responsible for developing approval criteria, policy, and guidance material are familiar with the limits and advantages of the technology. They may need systematic exposure to the technology through direct experience, operations reports, and formal instruction before they can develop the materials defining operating limits and requirements necessary for system implementation. In addition, the staffing needed to prepare the required directives and guidance within the time available prior to IOC exceeds current AFS staffing. Table 7 is a summary of AFS requirements for technical support needed to prepare the directives and guidance material necessary for implementing satellite navigation by the date of WAAS commissioning.

Table 7, AFS Requirements for Technical Support

Support Activity	Product Supported
WAAS receiver flight demonstrations	Changes to the AIM, Practical Test Standards, Inspectors Handbooks,
Handbook job aid: updated	Inspectors Handbooks
Support for technical writing	ACs
Support for SOIT	Implementation policy

7.3.3 Flight Procedures

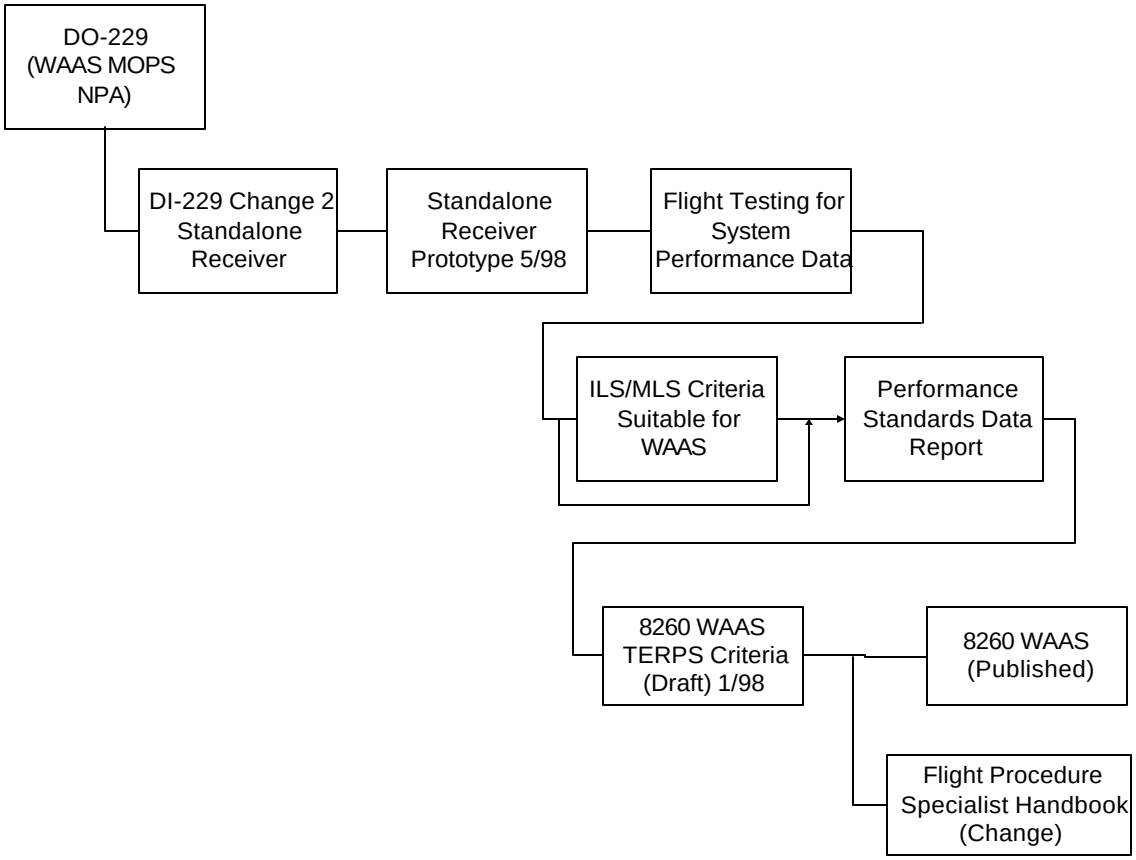
The FAA will require new flight procedures and obstacle clearance assessment criteria in order to capitalize on the benefits of WAAS, such as increased precision of navigation and the freedom of the signal in space

from terrain constraints. New procedures and criteria can also take advantage of new certification concepts such as RNP. Both the Flight Standards Service and Aviation System Standards have important responsibilities in this arena. The AFS Flight Procedures Standards Branch (AFS 420) serves as a focal point for all matters relating to airspace and cartographic programs. This branch addresses obstruction evaluation case appeals and is the primary interface for industry on matters relating to instrument procedures criteria. The Flight Procedures Branch (AFS-440) develops obstacle clearance criteria for the design of instrument flight procedures. The Standards Development Branch (AFS-450) empirically determines the system and pilot performance data upon which to base the procedures design criteria.

These performance data must be collected through flight testing to be valid. Such testing must include the use of TSO-certified receivers or similar avionics, and so is paced by their availability.

Figure 4 illustrates the sequence of major events necessary to develop the design criteria for GPS/WAAS instrument approach procedures. The ultimate goal of this activity is a working draft of Order 8260.WAAS, which specifies the design criteria for GPS/WAAS approaches. This must be available to procedure design specialists in order to develop these approaches, and is a pacing item for that activity. The receiver prototype is required for TERPS flight data to be collected, and this receiver probably will be developed before Change I or II to the MOPS is published. The TERPS for GPS/WAAS are expected to be available in April 1998, 15 months before commissioning. Table 9 indicates the dates by which major milestones must be accomplished if the design of the procedures is to be initiated as scheduled.

Figure 4, Sequence of Events Required for the Development of GPS and WAAS Instrument Approach Procedure Design Criteria



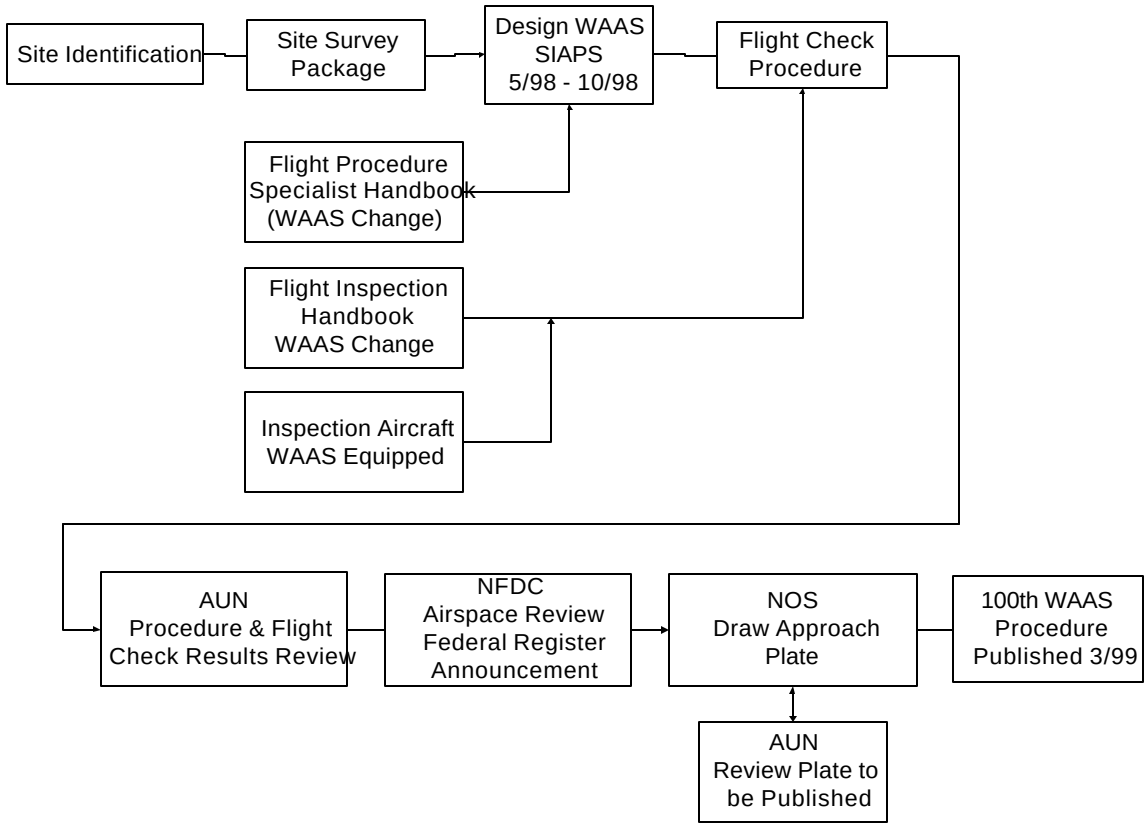
Aviation System Standards, part of the Air Traffic Service, designs the individual approach procedures according to published procedure criteria and with regard to survey information describing physical

characteristics of the airport. Regional offices compile and provide the survey data. These include weather source, terrain layout with obstructions, the results of the NOS survey for precision approaches, and the course to be flown by the aircraft.

Once the design criteria are available, it normally takes about a year to develop an approach, from survey package assembly to publication of the instrument approach procedure charts (IAPC). This includes the three months it takes from the time the Flight Data Center receives the design specifications of the procedure, after flight check, to publication of the procedure. Requests for additional information for the survey package, resolution of airspace issues, and sequential processing of information for approvals contribute to the length of this development period. Most of the 3D approaches to be developed for commissioning will be based upon existing ILS procedures. The basic trapezoidal obstruction clearance surfaces will be derived from existing ILS and MLS criteria, and some of the activities normally conducted in sequence will be done concurrently. It may therefore take much less that the year normally required to develop and instrument approach procedure, from initiation to publication of the IAPCs.

Figure 5 illustrates the sequence of major events and dependencies required to develop an instrument approach plate from site identification to publication. Site selection is usually done at the regional level and prioritization criteria have been developed for that purpose. However, high priority will be given to sites within some predetermined distance from a WAAS reference station desiring an ILS replacement. Reasonable proximity to reference stations is desirable until operational data can be collected on ionospheric spatial corrections. ILS replacements take advantage of existing survey data and facilitate ILS decommissioning. One hundred approaches (50 2D and 50 3D) will be published in time for WAAS commissioning.

Figure 5, Sequence of Major Steps Required for Development and Publication of WAAS Instrument Approach Procedure Chart



Policy on WAAS procedures development that has been sponsored by the SOIT calls for the concurrent development of a 2-D approach and 3-D approach at each of 50 runway ends prior to the WAAS commissioning date. This is cost-efficient, since a 2-D approach developed concurrently with a 3-D approach is only 50% more than the cost of the 3-D development. The non-precision procedure, based on TSO-C129 criteria, will provide approach capability for the WAAS 2-D receiver and provide a transition period for the earlier receiver. Thus, a total of 100 approaches at 50 runway ends will be developed by the WAAS commissioning date. A total of 1000 approaches will be developed the following year.

Table 10 shows the development schedule for only the first 100 approaches. This plan will be updated later to show scheduling for the remaining 8100 approaches. Note that this schedule is dependent on the timely development of the WAAS criteria. Slips in that development will result in slips of the same degree in the remaining activities. Incomplete or inaccurate survey packages, and potential delays in resolving airspace issues with air traffic are other possible points of delay.

Table 8, Major Milestones for Development of TERPS Design Criteria for 2-D and 3-D GPS/WAAS Approaches

Requirement	Complete
DO-229, Change 2, selected specifications	4/97
Receiver Prototype	8/97
Fight testing and validation of WAAS for standards	1/98
8260.WAAS (TERPS criteria) published	4/98

Table 9, Schedule of Milestones Necessary for Flight Check Requirements

Milestone	Complete
GPS/WAAS receivers delivered	8/97
STC engineering	2/98
Inspection aircraft equipped	5/98
Flight check order	8/98
Inspector training	9/98
Inspection of first 50 runway ends	5/99

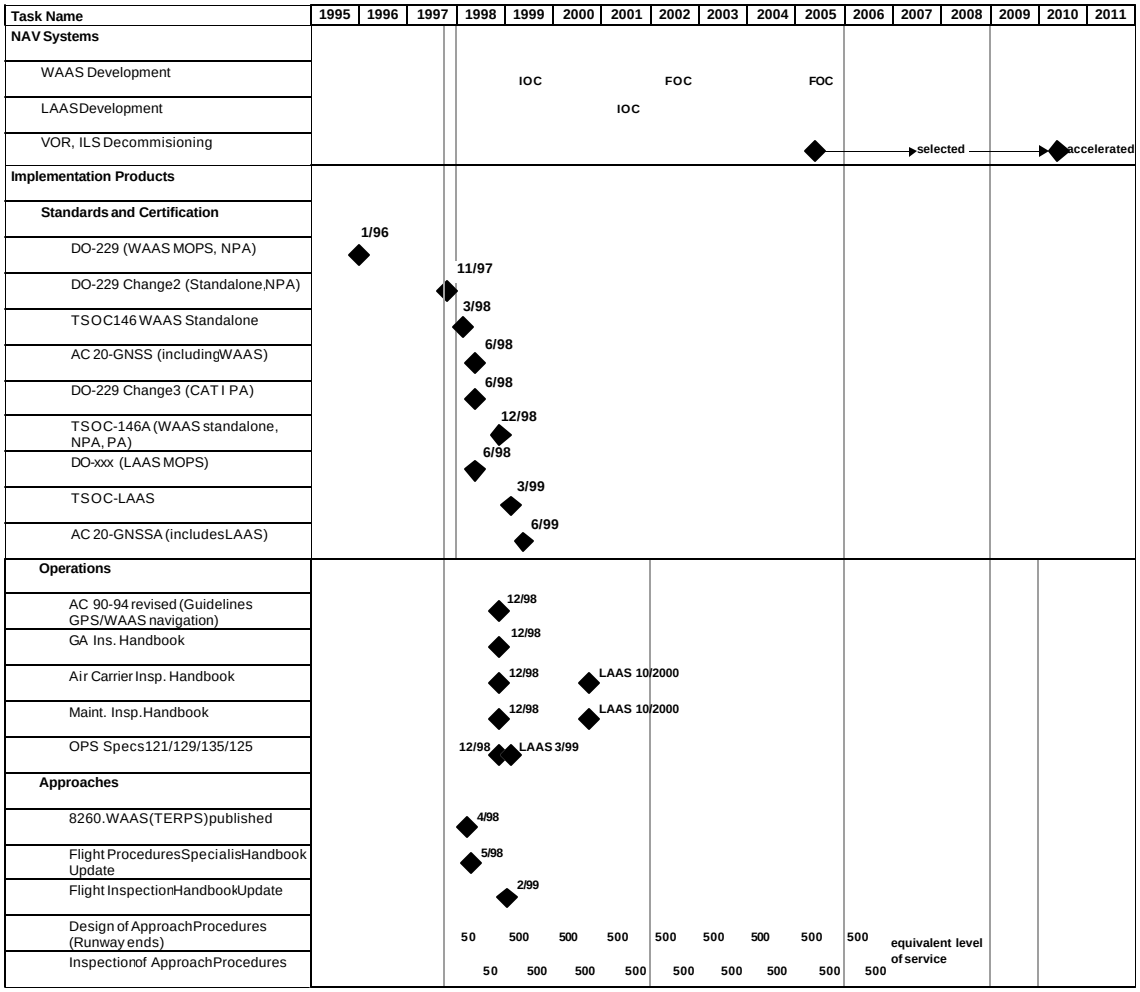
Table 10, Milestones schedule for Development of GPS/WAAS Standard Instrument Approach Procedures at 50 runway ends

Milestone	Complete
Change to Flight Procedures Specialist Handbook	5/98
Initial list of sites for WAAS	8/98
Initial survey information provided	7/98
Change to Flight Inspection Handbook	2/99
Design of approach procedures	2/99
Flight check of procedures completed	5/99
Instrument Approach Procedure charts published	7/99

Table 11, Requirements for Technical Support for Procedures

Support Activity	Product Supported
Automated approach procedure design Assistance in flight checking Management tool for development of procedures	Approach procedures
Contractor for Phase III surveys	Data package for approaches
Contractor support for Cat I approach criteria	Cat I approaches
Conversion to digital IAP charts	Graphing WAAS procedures
Criteria development	TERPS
Travel funds for SPIT	Approach procedure implementation

Figure 6, Schedule Of Products, Commissionings, And Decommissionings



8. Appendices

These may include organizational charters, an acronym list, a glossary, or other supplemental information.